EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN

Mathematisch-
Naturwissenschaftliche
Fakultät

Der Dekan

Promotionsvortrag am

06.11.2026, 14:00 Uhr

Gebäude: Hörsaalzentrum, Raum: 7E02

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Geometric characterisations of physical invariants of isolated systems

Berichterstatter*in 1: Prof. Dr. Cederbaum

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Abstract:

Physical properties of isolated gravitational systems are often described in terms of asymptotic coordinates. However, the absence of a preferred coordinate system gives rise to several difficulties, including coordinate-dependent quantities that fail to transform covariantly and convergence criteria whose geometric or physical significance is unclear.

In this talk, we address two such issues in the setting of initial data sets for general relativity, aiming to characterize asymptotic properties through geometric rather than coordinate-dependent constructions.

First, we characterize asymptotic Euclideanity, which describes the asymptotic geometry of isolated gravitational systems, in terms of the existence of a foliation by surfaces of constant spacetime mean curvature (STCMC). While Cederbaum and Sakovich (2021) established the existence of such a foliation in asymptotically Euclidean initial data sets, we prove the converse implication, thereby obtaining a geometric characterization of asymptotic Euclideanity. Our approach is constructive and relies on a careful analysis of the Laplace operators induced on the leaves, together with elliptic estimates, to construct a coherent basis of eigenfunctions along the foliation. This yields a coordinate system determined by the geometry of the foliation, which also appears naturally adapted to the STCMC center of mass.

Second, we investigate the definition and convergence of conserved quantities, focusing in particular on angular momentum. We present a result demonstrating that the classical Regge–Teitelboim parity conditions, commonly imposed to ensure convergence of coordinate-based definitions, are not necessary for the existence of well-defined angular momentum. In the axisymmetric setting, we further introduce a geometrically motivated definition of angular momentum based on the STCMC foliation, which agrees leaf-wise with the Komar angular momentum.